STANDARDS AND PRACTICES OF LOW-RISE WOODEN BUILDINGS IN JAPAN

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DOI: https://doi.org/10.59382/hnkh17-ibst.2025.ses2-20

ABSTRACT: This paper reviews Japan's standards for low-rise wooden buildings, focusing on structural safety, thermal performance, and fire resistance under the Building Standards Act. It also presents Life Design Kabaya's initiatives, such as CLT wall experiments, energy-efficiency measures, and ministerial certifications. These examples illustrate how Japan has built a reliable framework for safe and sustainable wooden construction, with implications for international adoption, including in Vietnam.

KEYWORDS: Wooden frame construction; structural performance, thermal insulation, fire resistance, CLT, building standards Act, sustainable housing.

1. INTRODUCTION

In Japan, the wooden frame construction method has long been a cornerstone of residential architecture. Currently, approximately 70% of wooden houses in Japan are built using this technique, valued for its technical reliability and construction flexibility. Compared to steel-frame or reinforced concrete construction, wooden construction emits significantly less carbon dioxide (CO_2) during manufacturing and construction, making it an environmentally friendly method that has attracted considerable attention. Amid the global push for carbon-neutral societies, the increased adoption of wooden construction is gaining importance as a key component of sustainable development, contributing to environmental conservation.

In the future, wooden construction technology is expected to make a significant contribution to environmental preservation and protection worldwide, not only in Japan. Against this backdrop, Life Design Kabaya Co., Ltd. (hereinafter referred to as *LDK*) took its first step toward overseas expansion in 2019 by establishing a subsidiary in Vietnam and launching a local wooden housing business. In 2022, we collaborated with the Institute of Construction Science and Technology (IBST) under Vietnam's Ministry of Construction to implement a demonstration project of wooden frame construction within the institution's facilities. Furthermore, with the aim of promoting and ensuring the quality of wooden frame construction in Vietnam by 2025, the recently announced Building Technology Standards (TCCS) are currently under development, with our company working together with IBST on their formulation.

Figure 1: Wooden building on the IBST premises

In the design and construction of buildings using wooden frame construction, evaluation methods and design standards based on the Building Standards Act and related regulations are applied to fundamental aspects such as structural performance, thermal performance, and fire resistance. Ensuring compliance with these standards is directly linked to securing the safety and comfort of buildings. In this report, we summarize the relevant laws and technical standards in Japan related to low-rise wooden buildings (structural safety, earthquake resistance, thermal environment performance, etc.), which served as one of the references in formulating the

TCCS technical standard. In addition, through examples undertaken by LDK, we explore the potential and future prospects for the international development of wooden frame construction.

2. STANDARDS AND EXAMPLES RELATED TO STRUCTURAL PERFORMANCE

One of the fundamental performances to be ensured in low-rise wooden buildings is structural performance. Within this, structural verification in low-rise wooden frame construction can generally be divided into two approaches: compliance with the specifications defined in the Building Standards Act, or structural analysis based on allowable stress design calculations. Both approaches ensure conformity with legal standards for structural safety.

2.1. Overview of specifications

The specifications for materials are defined in the Building Standards Act and other related laws and regulations. The main requirements include: ① Calculation of wall quantity, ② Provision and verification of column diameter, ③ Balance of bearing wall arrangement, ④ Specifications of column-head and column-base hardware. In addition, since the structural calculation method is simplified, it is applied only to small-scale buildings of up to two stories, with a total floor area of 300 m² or less and a building height of 16 m or less. Regarding ①, the required bearing wall quantity (required wall quantity) to resist horizontal forces (earthquake force and wind pressure) can be calculated in a simple manner. The required bearing wall length per unit floor area (e.g. cm/m^2) which is multiplied by the total floor area, is determined based on factors such as floor height, number of floors, roof type, and exterior wall specifications. Conversely, the actual bearing wall performance (existing wall quantity) of a building is calculated by multiplying the wall length by the wall factor (an index showing wall performance) indicated for each specification in the ministerial notifications, or the wall factor of the Minister-certified specifications, and confirming that it exceeds the required wall quantity. ② A dedicated tool is used to calculate the minor cross-sectional dimensions of columns, based on the loads and the bearing area specified in the building standards. ③ Standards (the quartering method) are also provided for the balance of wall arrangement, ④ For the safety of column-head and column-base joints, regulations stipulate that the joint specifications can be determined by a simple calculation called the N-value calculation. While this places certain restrictions on design flexibility, it offers a straightforward mechanism to ensure structural safety. Furthermore, under the Act on the Promotion of Quality Assurance for Housing (hereinafter referred to as the Housing Quality Assurance Act), performance grading has been established and standards have been raised. In addition, the safety verification of horizontal structural elements (floors and roof surfaces) through the introduction of the floor magnification factor has been required. By conducting more extensive checks and verifications than the standard law, this framework establishes a system that ensures higher earthquake resistance performance.

2.2. Overview of allowable stress design calculation

The allowable stress design calculation method verifies safety by comparing the stresses acting on each structural component with its allowable stress capacity. For the horizontal forces on the building, seismic force is calculated using formulas (1) and (2), while wind pressure is calculated using formulas (3) to (5).

$$Q_{Ei} = C_i \times \sum W_i \quad (1)$$

$$C_i = Z \times R_t \times A_i \times C_0 \quad (2)$$

Z： Seismic zone factor;

Rt：Vibration characteristic factor;

Ai：Story shear force distribution factor;

C_0 : Standard shear force factor:

$$Q_{wi} = q \times \sum (C_f \times A_i) \quad (3)$$

Qwi： Wind pressure on floor i

q : Velocity pressure

$$q = 0.6EV_0^2 \ (N/m^2) \quad (4)$$

$$E = E_r\ 2G_f \quad (5)$$

V_0 : Basic wind speed

G_f : Gust influence factor

E_r : Factor representing the vertical distribution of average wind speed

When $H>Z_b$、$E_r = 1.7\times (H' / Z_G)\ \hat{}\ \alpha$

When $H\leq Z_b$、 $E_r = 1.7\times (Z_b / Z_G)\ \hat{}\ \alpha$

H’: The larger of H or Z_b

H : Average height of the building

Z_b, Z_G, α : Values determined by the ground surface roughness classification

C_f :Wind force factor (factor determined by the building's shape and location)

A_i : Projected area of floor i.

The calculated horizontal forces are distributed across the entire structural frame, and the shear force borne by each bearing wall is calculated based on the stiffness ratio of each section. The allowable shear capacity of each section is evaluated either by multiplying the wall factor of the bearing wall by 1.96 kN, or by using the in-plane shear strength (kN/m) obtained through specified testing. Compliance is confirmed when the allowable shear capacity of each section exceeds the calculated shear force. For horizontal structural elements (floors and roofs), the allowable shear strength specified in the floor standards must also exceed the shear force generated between effective bearing wall lines, in the same way as for walls. Wall layout is further verified to ensure balance, the eccentricity ratio calculated using the quartering method or by measuring the deviation between the building's center of gravity and center of rigidity, must be 0.3 or less. It is confirmed that the allowable strength of each component and joint exceeds the stress acting on them. This method provides greater design flexibility compared with the prescriptive specifications, making it possible to design buildings with asymmetrical floor plans and large openings. There are differences between Japan and Vietnam in the way external forces are defined, especially seismic forces, which depending on specific conditions tend to be higher in Japan. However, since the TCCS standard also incorporates Vietnamese perspectives, it can be considered an evaluation method suitable for Vietnam.

2.3. Evaluation of wall performance

Regarding the evaluation methods for the wall factor of bearing walls and the short-term standard shear strength, as described in 2-1 and 2-2, these are indicated in *"Allowable Stress Design for Wooden frame construction Housing"* [1], and are referenced in the acceptance inspection for the TCCS. The following introduces an example of an experiment conducted by LDK, in which CLT facings were applied as bearing walls in the living/dining/kitchen area of a conventional frame house.

2.3.1. Test specimen overview

The test specimens consisted of seven types (one specimen per type), defined by the following parameters: column internal height (four variations), number of L-shaped metal fittings, screw length of the L-shaped fittings on the column side (two variations), and the presence or absence of filler material. A list of the specimens is provided in Table 2-3-1, and their shapes and dimensions are shown in Figure 2-3-1. The specimens were composed as follows: CLT face material (strength classification Mx60-3-3, thickness 60 mm); beam material of 105 mm × 180 mm (Douglas fir lumber); column and base material of 105 mm × 105 mm (cedar lumber); and structural plywood (thickness 24 mm) for the floor above the base. For each joint, columns, bases, and beams were fastened using HD metal fittings. Bases and floor plywood were connected with N75 nails at 75 mm spacing. Columns, beams, and bases (floor plywood) were attached to the CLT face material with L-shaped metal fittings using screw connections. Height-adjusting filler material was connected to beams with screws and plate fittings, and to columns with screws and corner fittings.

2.3.2 Test method and evaluation method of test result

The in-plane shear tests on the walls were conducted by installing the specimen in the testing apparatus as shown in Figure 2-3-2, with the column bases fixed. The applied force was alternating between positive and negative forces, three cycles at each apparent shear deformation angle of 1/450, 1/300, 1/200, 1/150, 1/100, 1/75, and 1/50 rad, Testing continued until the load decreased to 80% of the maximum load or the deformation reached 1/15 rad or greater. The test results were evaluated by fully elastoplastically modeling the envelope of the load-deformation relationship to calculate characteristic points to determine the short-term design strength. The wall factor was then derived without reduction for variability. All test and evaluation methods followed *"Allowable Stress Design for Wooden frame construction Housing"* [1].

Table 2-3-1: List of test specimens

Test specimen name	Column internal height (h) (mm)	Number of L-shaped metal fittings		Screw length (mm)	Live
		CLT-beams and flooring	CLT-columns		
Test specimen①	2733	1	3	45	No
Test specimen②	2733	2	4	45	No
Test specimen③	2673	2	4	45	No
Test specimen④	2673	2	4	45	Yes
Test specimen⑤	2613	2	4	45	No
Test specimen⑥	2613	2	4	(Beam)45 (Column site)75	No
Test specimen⑦	2553	2	4	45	No

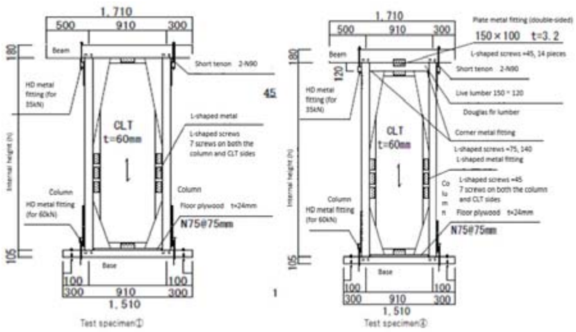
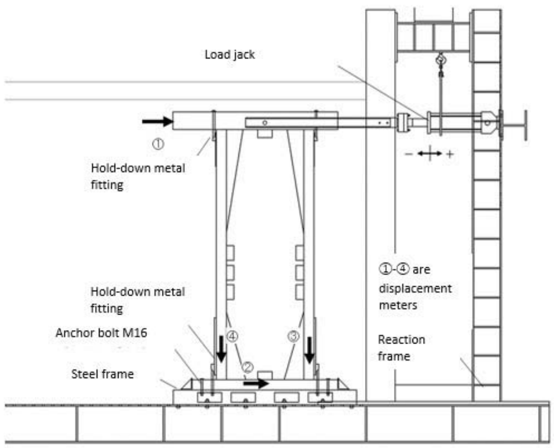


Figure 2.3.1: Diagram of test specimen



Installation Figure 2.3.2: diagram of test specimen

Table 2.3.2: List of characteristic values

Test specimen	Maximum load Pmax	Deformation at maximum load (δ)(Pmax)	Yield point deformation (δv)	Ultimate load (Pu)	Ultimate deformation (δu)	Dustility fator (μ)
	[kN]	[rad]	[rad]	[kN]	[rad]	
Test specimen①	24.86	0.049	0.023	22.7	0.069	2.96
Test specimen②	32.01	0.048	0.022	29.45	0.066	3
Test specimen③	33.09	0.057	0.024	29.99	0.058	2.46
Test specimen④	30.57	0.04	0.021	26.78	0.042	2
Test specimen⑤	38.6	0.068	0.025	35.21	0.07	2.81
Test specimen⑥	41.82	0.067	0.029	37.61	0.07	2.41
Test specimen⑦	34.19	0.037	0.02	30.59	0.043	2.18

Table 2-3-3 Short-term standard shear strength and wall bracing factor

Test specimen	Evaluation value per unit length						Wall magnification conversion
	Py	2/3Pmax	P120	Pu*0.2/Ds	Pu	Standard shear force	
	[kN/m]	[kN/m]	[kN/m]	[kN/m]	[kN/m]	[kN/m]	
Test specimen①	13.33	18.21	10.41	11.05	24.92	10.41	5.31
Test specimen②	19.39	23.45	14.54	14.49	32.37	14.49	7.39
Test specimen③	20.19	24.24	14.58	13.06	32.96	13.06	6.66
Test specimen④	18.09	22.40	12.90	10.19	29.43	10.19	5.20
Test specimen⑤	24.29	28.28	16.19	16.62	38.69	16.19	8.26
Test specimen⑥	25.46	30.64	15.13	16.16	41.33	15.13	7.72
Test specimen⑦	19.06	25.05	16.09	12.32	33.61	12.32	6.28

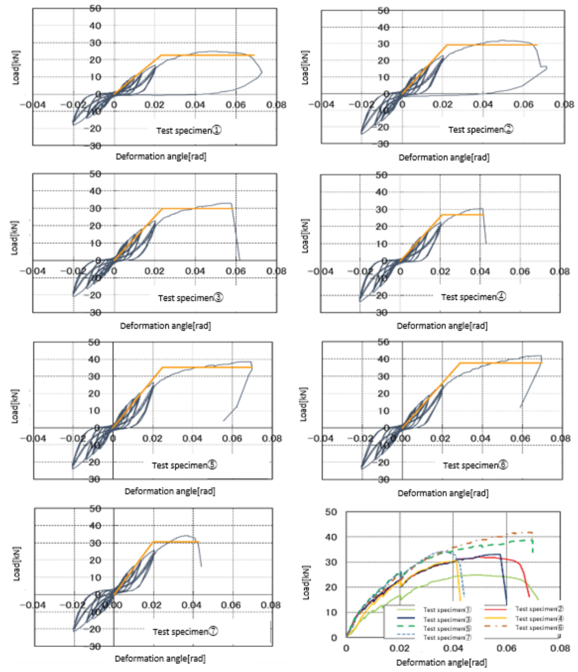


Figure 2.3.3: Load-deformation relationship

2.3.3. Test Results

1) Load-deformation relationship

The relationship between load and deformation angle for each specimen is shown in Figure 2-3-2. Specimen ① had fewer connection hardware pieces than the others specimens, resulting in a lower maximum load of 24.86 kN, whereas the maximum loads of specimens ② to ⑦ all exceeded 30 kN. A similar trend was observed at small deformations. The highest maximum load was recorded for specimen ⑥, at 41.82 kN. This is attributed to the 75 mm-long connection screws on the column side, which were longer than those used in the other specimens, providing superior connection performance and consequently higher strength.

2) Fracture Characteristics

No significant damage was observed in any of the test specimens up to a deformation of 1/75 rad. In specimen ③, slight cracks appeared in the base at a deformation of 1/50 rad, while in specimen ⑤, a small gap occurred between the subfloor and the base material. At a deformation of 1/30 rad, except for specimen ⑥, lifting of the floor plywood due to rotation of the CLT (Photo 2-3-1) and deformation and loose screws at the column-to-CLT joints (Photo 2-3-2), and deformation of the hold-down metal fittings between the base and columns and cracking of the columns (Photo 2-3-3), were confirmed. The causes of the observed failure and resulting load reduction were cracking of the tensile-side columns or loose screws at the joint with CLT connections.

Left: Photo 2-3-1 Lifted floor plywood
Center: Photo 2-3-2 Loosen the screw of the L-shaped metal
Right: Photo 2-3-3 Column cracking at HD metal fitting

3) Characteristic values

The results are shown in Tables 2.3.2 and 2.3.3. All test specimens satisfied the requirement of a wall factor of 5 or more (wall factor = short-term shear strength per unit length (kN/m) / (1.96 kN)). Comparing test specimens ① and ②, which differed only in the number of L-shaped metal fittings, confirmed that while the deformation at the time of strength development remained the same, increasing the number of connectors significantly improved the strength. Furthermore, comparing test specimens ⑤ and ⑥, which differ in screw length on the column-side connections, the longer screws resulted in greater yield strength and larger displacement at yielding, which in turn affected the conversion to wall factor. Comparing specimens ②, ③, ⑤, and ⑦ with different column heights showed no clear trend, suggesting that the effect of height within this range is likely to be small.

4) Summary

All test specimens exhibited a wall factor of 5 or higher, confirming that they meet the performance requirements for walls in two-story wooden frame constructions. Additionally, the results confirmed that both the number of L-shaped metal fittings and the screw length influence wall performance.

3. STANDARDS AND EXAMPLES OF THERMAL PERFORMANCE

3.1. Compliance with energy conservation standards

In Japan, starting in April 2025, compliance with energy-saving standards (the building envelope performance standard and the primary energy consumption standard for housing) will be mandatory for all newly constructed houses, regardless of construction method. The purpose is to contribute to the realization of a decarbonized society through thorough energy-saving measures in the building sector and the expanded use of wood as a carbon sink. Compliance can be verified either through specification regulations or by calculation.

The building envelope performance standards include the average heat transfer factor of the envelope (UA value, Formula 3.1) and the average solar heat gain factor during the cooling period (ηAC value, Formula 3.2). Standard values for both are region-specific (Figure 3.1), and they must be below the standard values (Table 3.1, Table 3.2).

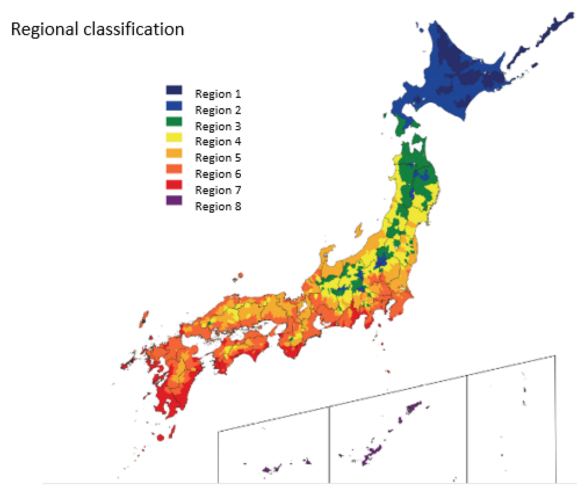


Figure 3.1: Regional Classification

Table 3.1: U_A standard values

Regional classification	1	2	3	4	5	6	7	8
U_A	0.46	0.46	0.56	0.75	0.87	0.87	0.87	—

Table 3.2: ηAC standard values

Regional classification	1~4	5	6	7	8
η_{AC}	—	3	2.8	2.7	6.7

$$U_A\,(W/m^2.\ K) = \frac{\text{Total.heat}}{\text{Total emielope}}$$

= Total heat loss through the building envelope per unit temperature difference q / Total envelope area (3.1)

Total heat loss through the building envelope per unit temperature difference q

$$q=\sum(A_i \times U_i \times \theta_i)$$

A_i: Area of each envelope part (m²)

U_i: Thermal transmittance of each envelope part (W/m²K)

θ_i:Temperature difference factor (correction factor for temperature difference with adjacent spaces)

※Envelope part includes ceiling (or roof, if the attic or ceiling cavity is not connected to the outside air), walls, floor, and openings.

η_{AC} =(Total solar heat gain per unit solar radiation intensity / Total envelope area) × 100 (Formula 3.2)

Total solar heat gain per unit solar radiation intensity

=∑ (Solar heat gain factor of each part × Shading effect factor of each part × Orientation factor of each part × Area of each envelope part)

Primary energy consumption performance is required to have a BEI value of 1.0 or less, calculated using Formula 3.3.

BEI =Design primary energy consumption / Standard primary energy consumption (Formula 3.3)

- Standard primary energy consumption is the sum of the following values ① through ⑤ for standard specifications.

- Design primary energy consumption is the sum of the following values ① through ⑥ taking into account energy-saving measures

① Energy consumption for air-conditioning/heating and cooling.

② Energy consumption for ventilation.

③ Energy consumption for lighting.

④ Energy consumption for hot water supply.

⑤ Other (household appliances, etc.).

⑥ Reduction by efficiency-improving equipment (such as photovoltaic equipment).

Calculation tools and web-based programs are provided for each value, ensuring an environment where business operators can perform calculations and verification.

3.2. Other standards

Another relevant standard is the Housing **Quality Assurance Act**, under which insulation performance is evaluated on a seven-grade scale (with grade 7 being the highest). The evaluation is based on the UA value and the η_{AC} value, as shown in Table 3.3 and Table 3.4, with the lower grade being applied. For compliance with the energy efficiency standards mentioned in the previous section, insulation performance of grade 4 or higher (for residential buildings) is required. At LDK, while ensuring compliance with the energy efficiency standards, grade 6 insulation is adopted as the standard specification.

Table 3.3: Insulation performance grade U_A value

		Regional classification							
		1	2	3	4	5	6	7	8
Grade	7	0.20	0.20	0.20	0.23	0.26	0.26	0.26	–
	6	0.28	0.28	0.28	0.34	0.46	0.46	0.46	–
	5	0.40	0.40	0.50	0.60	0.60	0.60	0.60	–
	4	0.46	0.46	0.56	0.75	0.87	0.87	0.87	–
	3	0.54	0.54	1.04	1.25	1.54	1.54	1.81	–
	2	0.72	0.72	1.21	1.47	1.67	1.67	2.35	–
	1	–	–	–	–	–	–	–	–

Table 3.4: Insulation performance grade η_{AC} value

		Regional classification			
		5	6	7	8
Grade	7	3.0	2.8	2.7	–
	6	3.0	2.8	2.7	5.1
	5	3.0	2.8	2.7	6.7
	4	3.0	2.8	2.7	6.7
	3	4.0	3.8	4.0	–
	2	–	–	–	–
	1	–	–	–	–

In Japan, with the aim of reducing environmental impact, a building is defined as a ZEH (Net Zero Energy House) if it achieves an insulation grade of 5 or higher and reduces its annual primary energy consumption to nearly zero through the use of renewable energy. The goal is to ensure that, by 2030, newly built detached houses on average achieve energy efficiency performance at the ZEH level.

In Vietnam, energy-saving standards for large-scale buildings (QCVN 09:2017/BXD) have already been established. However, for small-scale residential buildings such as two-story houses, which will become mandatory in Japan under the 2025 revision, this has not yet been required in Vietnam.

Due to Vietnam's climatic conditions, where cooling energy demand predominates and solar shading for openings is an important factor, these aspects significantly affect the Building Energy Index (BEI). Therefore, by continuing to conduct studies and verifications on residential-scale buildings, more appropriate wooden frame construction specifications suited to Vietnam's conditions are expected to be developed.

3.3. Examples

As an important factor in maintaining the insulation performance standards described in 3-1 and 3-2, the airtightness performance of the building is cited. The C-value (equivalent gap area) is an indicator of the amount of air gaps in a building.

C-value = Total gap area of the house (cm^2) /Total floor area (m^2)

※ The standard for highly airtight houses is a C-value of 1.0 or less.

At LDK, C-value measurements are conducted for constructed houses, with confirmed results ranging between **0.27 and 1.0.**

Photo 3.1: Airtightness measurement (C-value Measurement)
Left: Measurement scene
Right: Measurement result monitor

4. STANDARDS AND EXAMPLES OF FIRE RESISTANCE AND FIRE PREVENTION PERFORMANCE

In Japan, the conventional wooden frame construction method requires ensuring both fire resistance and fire prevention performance in the event of a fire. Along with recent revisions to the Building Standards Act, standards and ministerial certifications concerning fire resistance and fire prevention performance have been established, promoting the improvement of fire resistance and fire prevention performance of wooden buildings. Below is an overview of the main fire resistance and fire prevention requirements in Japan.

4.1. Legal Framework and Classification

Under Japan's Building Standards Act, fire resistance and fire prevention performance are broadly classified into three categories, as shown in Table 4-1

This classification is determined according to conditions such as the building's use, scale, height, and the fire prevention or quasi-fire prevention districts of the construction site. An overview of the various structure described in Table 4-1 is shown in Table 4.2.

Table 4.1: Structural Classification

Fire resistant buildings	Main structural parts (columns, beams, walls, etc.) must be fire-resistant structures, and openings must be equipped with fire-prevention facilities. The building is required to remain standing even after a fire.
Quasi fire resistant building	Main structural parts must be quasi-fire-resistant structures, and openings must be equipped with fire-prevention facilities. Required to resist collapse for a certain period of time in the event of a fire. Columns and beams must also be designed with a fire margin, and the wood (structural material) may remain exposed.
Other buildings (General wooden construction)	Buildings in which each part (exterior walls within fire spread range, openings, etc.) is constructed with fire-prevention structures and fire-prevention facilities.

Table 4.2: Various structures

Type	Purpose	Technical Requirements	Main Installation Locations/ Uses
Fire-Resistant Structure	Prevents structural collapse and fire spread.	Walls, etc.: Fire resistance of 60 minutes or more	Walls, columns, beams, roofs, floors, stairs
Quasi-Fire-Resistant Structure	Prevents fire spread and ensures evacuation time	45 minutes or more (30 minutes depending on the area)	Walls, columns, floors, eaves, stairs
Fire-Prevention Structure	Prevents fire spread from the outside	Bursts for 30 minutes or more	Exterior walls, eaves, and roofs
Fire-Proof Equipment	Prevents flames from entering through openings	Specified fire-resistance time (20 minutes or more)	Doors, windows, shutters, ventilation openings

In residential construction, in addition to the "Fire-Resistant Structure," "Quasi-Fire-Resistant Structure," and "Fire-Prevention Structure" defined by the Building Standards Act, the Ministerial Ordinance Quasi-Fire-Resistant Structure is also specified. The Ministerial Ordinance Quasi-Fire-Resistant Structure is a system developed to ensure fire safety based on the quasi-fire-resistant structure standard, but with more practical specifications. Especially in the case of low-rise wooden houses (three stories or fewer), although the regulations depend on whether the building site is located in a fire prevention district or a quasi-fire prevention district, there are few cases where they are built as fire-resistant buildings. In practice, the majority are quasi-fire-resistant structures, Ministerial Ordinance Quasi-Fire-Resistant Structure, and general wooden structures.

As part of the institutional development regarding fire resistance and fire prevention performance, the Building Standards Act was revised in 2000 and again in 2019, whereby rationalization related to fire resistance and fire prevention performance progressed, and the utilization of quasi-fire-resistant structures was promoted. Furthermore, with the amendment of the Act in April 2024, rationalization of fire prevention regulations for wooden structures and the promotion of wood use has advanced, and the institutional foundation supporting the use of wood in buildings is being established. As a result, the design flexibility and practicality of wooden buildings have expanded, contributing both to environmental impact reduction and the creation of a recycling-oriented society.

In Vietnam, according to the national standard QCVN 06:2022/BXD, although there are differences in scale and scope compared to Japanese standards, the requirements concerning building size, use, and the performance of each building component are defined. However, for low-rise wooden buildings, the level of regulation is not as detailed as in Japan. Nevertheless, in the TCCS, considerations such as building separation distance, evacuation routes, and interior material restrictions for rooms using fire are established with the highest priority given to life safety, achieving an equivalent level to Japanese standards.

4.2. Ministerial certification system

In the development of the technical foundation for fire-resistant and fire-preventive structures, the introduction of the Ministerial Certification System (a framework covering not only fire prevention but also structural design, equipment, and various construction methods) has made a significant contribution. Prior to 2000, it was possible to comply with the various structural categories shown in Table 4-2 solely through prescriptive specifications. However, following the revision of the Building Standards Act in 2000, structures certified by the Minister of Land, Infrastructure, Transport and Tourism as meeting the required performance standards also became permissible, expanding options beyond prescriptive specifications. The performance evaluation required for obtaining this ministerial certification is carried out by performance evaluation bodies designated by the government. Since then, businesses have actively pursued the acquisition of ministerial certification with the aim of improving design flexibility, constructability, cost efficiency, and practicality. As a result, it has become firmly established as a diverse means of ensuring fire resistance performance in today's wooden houses.

4.3. Examples

At LDK, with the aim of promoting the wider adoption of CLT, development has been carried out on CLT shear walls with a view toward application in detached houses. In this process, in order to make it possible to expose and utilize the CLT wood surface as an interior finish, the Ministerial Certification System described in 4-2 was applied, and ministerial certification for a 45-minute quasi-fire-resistance structure was obtained. This certification covered Type 1 of exterior wall specification and Type 2 of interior partition wall specifications. The test conditions for the interior partition specifications are shown in Photos 4.1 to 4.4, and the cross-sectional composition of the test specimen is illustrated in Figure 4.1.

The test was conducted by installing the specimen in a fire-resistance furnace, heating it for the prescribed time using the specified standard heating curve for furnace temperature, and confirming that the specimen did not burn through and that its strength did not decrease below the specified level.

Photo 4.1: Before the test

Photo 4.2: During the test

Photo 4.3: After the test

Photo 4.4: After the test

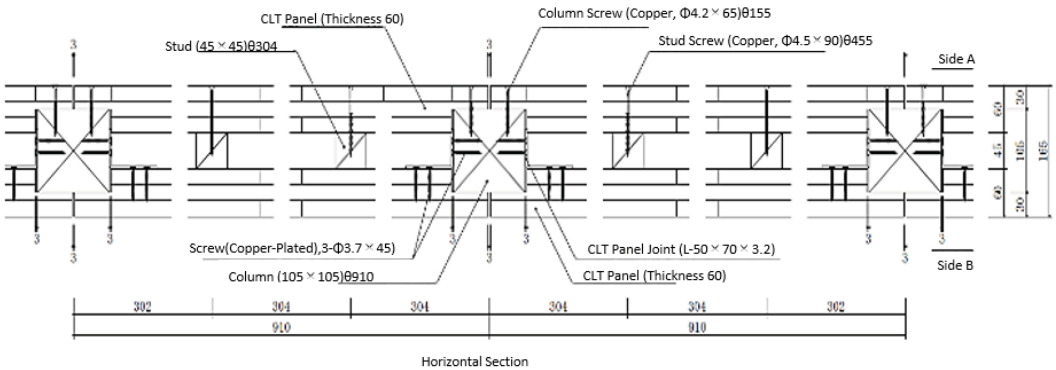


Figure 4.1: Cross-section of partition test specimen

5. FUTURE PROSPECTS

As described in this article, the conventional wooden frame construction method, which is widely used in Japan's low-rise wooden buildings, is supported by standards, systems, and frameworks grounded in laws and regulations covering structure, thermal environment, and fire resistance. These frameworks have been established in response to Japan's climate conditions and social demands. Recent revisions to the standards have also been moving in the direction of promoting greater use of wood, and various technological developments are being advanced by different businesses. Against this backdrop, LDK has integrated CLT, which is attracting attention as an environmentally friendly building material, into the traditional frame construction method, thereby promoting its adoption in detached houses and contributing to the establishment of standards in Vietnam. The development of wooden frame construction methods adapted to the climate and culture of each country, not just Japan, will expand the possibilities for sharing and developing the value of wooden architecture. It is hoped that Japanese wooden construction technologies will contribute to their global dissemination and contribute significantly to the creation of a sustainable architectural society.

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[1] Allowable Stress Design of Wooden Frame Construction Housing (2017 Edition), Japan Housing and Wood Technology Center.